THE USE OF CEMARA UDANG (*Casuarina equisetifolia*) FOR AGRICULTURAL PURPOSES IN THE SOUTHERN COAST OF YOGYAKARTA

Atus Syahbudin[1], Dwi Tyaningsih Adriyanti[2], Anisa Handayani[3], Hu Bai, Katsuya Osozawa[4], and Ikuo Ninomiya[5]

Abstract

An exploration along the Southern Coast of Yogyakarta and deep interview with 276 respondents in the Southern Coast of Kulon Progo and Gunungkidul Regencies had been conducting during January 2010 and February-May 2012. Respondents recognized that before the establishment of Casuarina equisetifolia they faced problems like strong wind in the agricultural land (81.6%), uncultivated land near the coast (20.3%), agriculture crops die because of salt water (17%), and others (11.3%). During 16 years the establishment of C. equisetifolia has been creating vegetative wind barrier due to Attims' tree architecture model. C. equisetifolia reduces the use of dried coconut leaf/blarak (29.3%) and objectifies green coastal landscape, which makes farmer, fisherman, inhabitant, visitor and merchant become pleasant. In addition, C. equisetifolia provides benefits as shady tree for agricultural nursery (10.9%), mulch (10.4%), fertilizer (3.3%), and many kinds (49.4%). Reduction in the use of blarak, mulch and purchased fertilizer will increase farmer's income because the cost of labor, fertilizer and mulch decrease.

Keywords *:-Casuarina equisetifolia; cemara udang; Attims' tree architecture model; coastal agriculture; agricultural use*

Introduction

Indonesia has 17,508 islands and 81,000 km of coastline which provide an excellent coastal resources, coastal communities, and culture. As an archipelagic country, coastal zones are one of the major ecosystems. They represent a habitat that is intermediate between the sea, the land and fresh waters with a complex and dynamic mixture of transitional conditions [1] [2]. The width of this zone varies as far as where the land meets the sea, and where the lithosphere, hydrosphere, and atmosphere meet and interact [3].

The Island of Java is one of five major islands in Indonesia. By the type of climate and rainfall varied, it has tropical rain forest, seasonal monsoon forest in Central and East

[1] Department of Bioresource Production Science , UGAS Ehime University, Matsuyama, Japan, E-mail: syahbudin_atus@yahoo.com
[2] Department of Silviculture, Faculty of Forestry, Universitas Gadjah Mada (UGM, Yogyakarta, Indonesia, E-mail: dtadrianti@ugm.ac.id
[3] Department of Social Economic of Agriculture, Faculty of Agriculture, UGM, Yogyakarta, Indonesia, E-mail: ayanisah@gmail.com
[4] Department of Agricultural Economic and Agribusiness, Faculty of Agriculture, Ehime University, Matsuyama, Japan, E-mail: ososago5503@agr.ehime-u.ac.jp
[5] Department of Forest Resource Biology, Faculty of Agriculture, Ehime University, Matsuyama, Japan, E-mail: mack@agr.ehime-u.ac.jp

Java [4], and mangrove forest [5] [6], also potentially a coastal forest that stretches along the coast of Java, especially southern coast. In the Southern of Java Island, the coast stretches from West Java, through Central Java and Special Region of Yogyakarta to East Java and directly border on Indian Ocean along more than 1400 km. These coastal areas become very important due to the existing of conservation area [7], sandy agricultural land [8] [9] [10], as well as its big contribution to regency and province's income from mining, tourism, cultural beach and fish landing ports [11] [12]. In other hand, poor families reside in these parts and exploit coastal areas considering limited fertile agriculture land. They face some problems like economic and ecology [9]. Fig. 1 shows three maps of the predicted economic opportunities of Special Region of Yogyakarta with most of Southern Coast still in low predicted economic opportunities (indicate with red color). Therefore it is needed the emphasis upon agricultural development for income and food security through management of the coastal zone [2] [13].

Began in October 1996, Universitas Gadjah Mada (UGM) established cemara udang, local name for *Casuarina equisetifolia*, from Lombang Beach, Madura Island, East Java Province into Samas Beach, Bantul Regency, Special Region of Yogyakarta [10] (Fig. 2). This project resulted that the sandy land's hind of *C. equisetifolia* stand possibly to be cultivated, nursery will be produced and tourism can be increased [14].

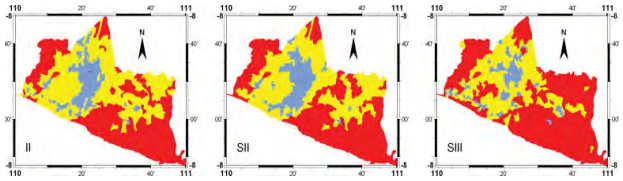


Figure 1. Modelling results of the predicted economic opportunities of Special Region of Yogyakarta. Model 1: Integrated Infrastructure (II), Model 2: Spatial Integrated Infrastructure (SII), and Model 3: Spatial Integrated Infrastructure Interdependency (SIII). Blue, yellow and red respectively represent high, medium and low economic opportunities (Map source : [15])

C. equisetifolia was then extensively continued to other places spread in the southern coast of Java Island and gives some benefits for local inhabitant [8] [9] [16] [17]. Success story of the establishment of *C. equisetifolia* that started sixteen years ago can to be a model for other coasts that have not previously productive. Furthermore, the present use of *C. equisetifolia*, in particular for agricultural purposes wants to be known through deep interview.

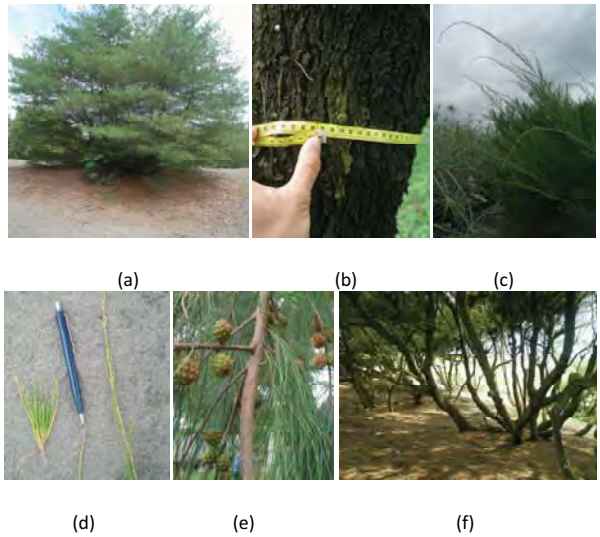


Figure 2. The morphology of cemara udang (*C. equisetifolia*): (a) crown, (b) bark, (c-d) leaf, like shrimp tails, (e) fruit and branchlets, (f) stem. The taxonomy of *C. equisetifolia* is described follows reference [18] [19] [20] [21] [22]. (photograph taken in 2009 by Atus Syahbudin)

Methods

Overview of Study Site

The Southern Coast of Special Region of Yogyakarta spreads across three regencies; border directly onto the Indian Ocean. These regencies are Kulonprogo, Bantul and Gunungkidul (Fig. 3).

Figure 3. The study site is along the Southern Coast of Special Region of Yogyakarta, Indonesia, which spreads across three regencies: Kulon Progo, Bantul and Gunungkidul (Map source: [15])

These parts constitute the southern of Eurasian Plate (Sunda Shelf), which converge the Indian oceanic plate formed the active volcanic arc in western Indonesia. When

exploded, volcanic material will be transported including to the Indian Ocean through rivers. The sandy beach and dune deposit in the Southern Coast of Yogyakarta is sand in 3rd order. Presentation of fine sand fraction increase and siltation became better than in Opak River and Progo River which stream down through Special Region of Yogyakarta Province and transport sand directly from Merapi Mountain and Sewu Hills to the Indian Ocean [23] [24]. Marine sediment and river-borne sediment in the estuary of the river form the dike and sand dune [5] [25]. Sand is moved along the coast by wave action, wind and currents. The wind speed in Samas Beach was 6.06 Mph in seashore and 6.33 Mph in foredune [8]. Whereas the wave's speed along Yogyakarta Coastline is between 3.8-23.3 N/second with high average was 0.5-1 meter [27]. Through this process and the type of climate and rainfall, the Southern Coast of Yogyakarta is generally barren with high porosity, low fertility, and limited water availability [12] [16].

Fig. 4 below presents the condition of infrastructure performance in the Southern Coast of Special Region of Yogyakarta.

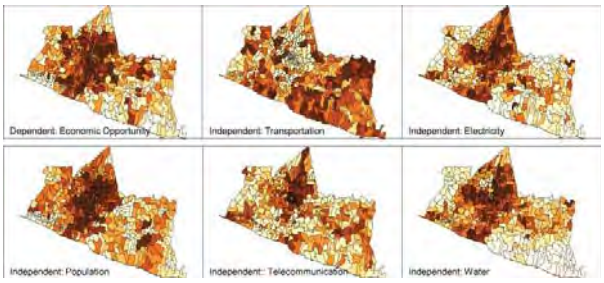


Figure 4. Spatial distribution of infrastructure performance in the Special Region of Yogyakarta. The dark colours represent higher values or better infrastructure performance (Map source: [15])

Time

We had been exploring along the Southern Coast of Special Region of Yogyakarta and interviewing deeply 276 respondents in January 2010 and February-May 2012. However literature review, observation and secondary data were collected since February 2008.

Sampling Techniques

Survey was conducted by exploring method along the Southern Coast of Special Region of Yogyakarta to investigate the formation and the presence or absent of *C.*

equisetifolia. This method explores each side of study site for gaining the data [27], include areas within Parangkusumo and Parangtritis sand dune and along the track near the coastline [28].

In order to find out the use of *C. equisetifolia* associated with agricultural purposes, we have been observing, taking photographs, and interviewing deeply 276 respondents who residing in the village near the Southern Coast of Kulon Progo and Gunungkidul Regencies. Twenty households from each village, limited to farmer and fisherman and certain merchant, were targeted to interview. Two interviewers had been asking respondents with a questionnaire sheet, which prepared to guide the interview (see the last page, after references). The elders and head of villages were interviewed firstly in order to get permission, more local information and history [29]. Some related publications also used to indicate *C. equisetifolia* has been utilized [30]. The result is explained by description.

Results and Discussion

Two Formations of C. equisetifolia in the Southern Coast of Special Region of Yogyakarta

It is clear that there were twenty-six beaches along the Southern Coast of Special Region of Yogyakarta where *C. equisetifolia* distribute (shown in Table 1). They were found in the rows formation (group) and another scattered as individual. The former was found mostly in the foredune in space between (3-5) m x (3-5) m (Fig. 5) and the latter was *C. equisetifolia* that artificially pruning from middle to the lowest branch [31].

Figure 5. Rows formation of *C. equisetifolia* was created for preventing agriculture land in Samas Beach in front of boundary land of gliricidia and peanut (left) and preventing embarkment in Kuwaru Beach (photograph taken by Atus Syahbudin in 2009, thirteen years after establishment of *C. equisetifolia* in Samas Beach)

C. equisetifolia has attims' tree architecture model. Attims' model has monopodial stem and some monopodial branches that grow continuous and orthotropic (Fig. 6) [33].

Figure 6. Attims' tree architecture model belong to *C. equisetifolia* (left), fact of *C. equisetifolia* in the coast (middle), and guidelines for recording axis persistence of *C. equisetifolia* (right) [34]

These characteristics allow *C. equisetifolia* to make the finely branched crown and densely branched with horizontal branches as the basis of species' suitability for planting as windbreak [34]. *C. equisetifolia* is apparently suitable for protecting sandy land from wind erosion and salt spray [8] [14].

TABLE I. Locations Where *C. Equisetifolia* Distributed

No	Name of Beach/Coast	Regency	Formation of *C. equisetifolia*
1	Trisik	Kulonprogo	Group, individual
2	Karangsewu		Group, individual
3	Bugel		Group, individual
4	Conggot		Group, individual
5	Garongan		Group
6	Karangwuni		Group
7	Pleret		Group
8	Glagah		Group, individual
9	Pandansimo	Bantul	Group, individual
10	Baru		Group, individual
11	Kuwaru		Group, individual
12	Patehan		Group, individual
13	Dewaruci		Group
14	Pandansari		Group, individual
15	Samas		Group, individual
16	Depok		Group, individual
17	Parangkusumo		Individual
18	Sand dune of Parangkusumo and Parangtritis		Group[a], individual
19	Parangtritis		Individual
20	Baron	Gunungkidul	Individual
21	Kukup		Individual
22	Sepanjang		Individual
23	Drini		Individual
24	Sundak		Individual
25	Krakal/Slili		Individual
26	Trengguli		Individual

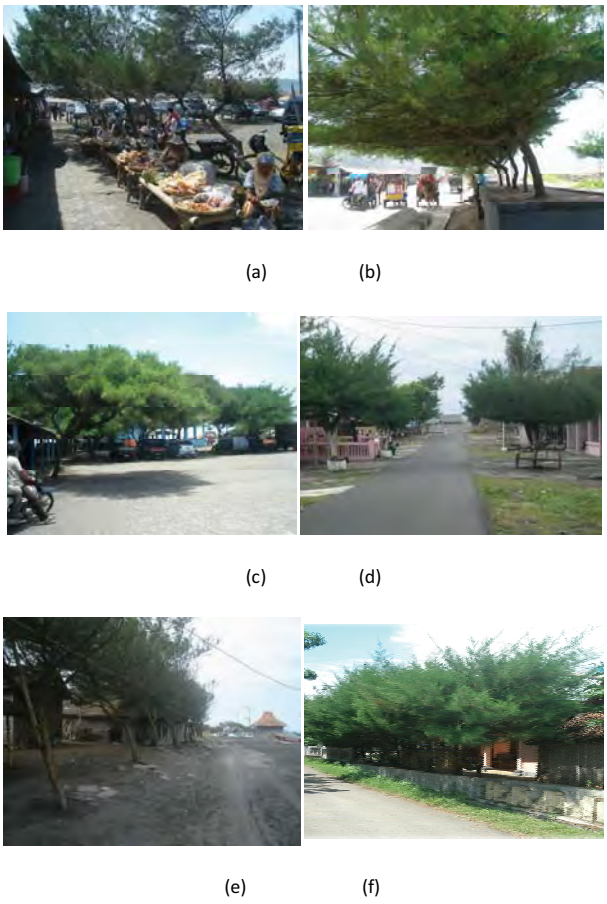
[a] the establishment of *C. equisetifolia* was in November-December 2011

Table 1 above shows that the most of *C. equisetifolia* in the Southern Coast of Kulon Progo and Bantul Regencies are in rows formation, except Parangtritis Beach and Parakusumo Beach. This Southern Coast of Kulon Progo and Bantul regencies where located between two rivers i.e. Opak River and Progo River have a relatively flat land and more water as shown in Fig. 4. Thus agricultural land and activities have been developing and becoming main economic resource. In the previously time, inhabitant used only pioneer vegetation to prepare cultivation in the sandy land, then acacia and gliricidia to shade crops [9] and to make boundary land clearly. However after the establishment of *C. equisetifolia*, mainly in the rows formation, wind speed can be reduced to 0.79 in seashore and 1.06 Mph in foredune compared with behind plantation in Samas Beach; soil temperature can be decreased to 8% and evaporation rate can be pushed down. Finally, sandy agricultural land contributed 14% of household income [8]. Compare with the exploration in 2008 [31], the current distribution of *C. equisetifolia* in the Southern Coast of Bantul become more widespread. They protected and increased the production of paddy field around November, then red onion in February, cayenne in May, and intercropping between red onion and cayenne from August [16].

In order to support the rows formation of *C. equisetifolia*, the presence of pioneer vegetation is very important, mainly rolling grass (*Spinifex littoreus*), screw pine (*Pandanus tectorius*), goat's convolvulus (*Ipomoea pes-caprae*) and crown flower (*Calotropis gigantea*) [17] [31]. Rolling grass (*Spinifex littoreus*) was the most successful pioneer vegetation for sand trapping and together brings dune stabilization [35]. Whereas in some sites in the Southern Coast of Kulon Progo and Bantul Regencies and all study sites in the Southern Coast of Gunungkidul Regency *C. equisetifolia* scatters landward in individual. They are artificially pruned from middle to the lowest branch [31]. We recorded that the presence of *C. equisetifolia* in individual associated with the need of shade, space, green landscape and protection. Green coastal landscape with better infrastructure performance, such as more water, electricity, transportation, telecommunication and population prompted more tourism areas, trade areas and wide residential such as in Parakusumo Beach and Parangtritis Beach. and nowadays also in Patehan Beach (Pantai Gua Cemara) and Baru Beach in Bantul Regency. The two latter demonstrates that some rows formation of *C. equisetifolia* changed to in individual due to tourism's needs (Fig. 7). Supporting from related agencies of local government makes this process faster.

Figure 7. Rows formation of *C. equisetifolia* was artificially pruned from middle to the lowest branch in order to support tourism in Baru Beach (left) and also in Patehan Beach (Pantai Gua Cemara) (right), Bantul Regency (photograph taken by Atus Syahbudin in February 2012)

In other hand, *C. equisetifolia* in individual apparently suitable for tourism area, trading area, parking area, wayside, rest area, and villages as shown in Fig. 8 below.



The use of *C. equisetifolia* in individual in the Southern Coast of Special Region of Yogyakarta: (a) shady tree in the trading area of Depok Beach, (b) shady tree in the tourism area of Parangtritis Beach, (c) shady tree in the parking area of Depok Beach, (d) wayside to Samas Beach, (e) shady tree in the fishing villages of Pandansimo Beach (f) shady tree and border tree in the village near the coast (photograph taken in January 2010 and February 2012 by Atus Syahbudin)

The Use of C. equisetifolia for Agricultural Purposes in the Southern Coast of Special Region of Yogyakarta

According to the part of interview result, which presented in Fig. 9, respondents recognized that they faced some problems before the establishment of *C. equisetifolia*. They agreed that strong wind in the agricultural land constitutes the biggest agricultural problem in the Southern Coast of Special Region of Yogyakarta (81.6%). Then respectively followed by uncultivated land closed to coast (20.3%); agricultural crops die because of salt water (17%); other agricultural problems like barren condition, hot weather and no shading (4.6%); sandy agriculture land (3.5%); difficult to obtain water (2.4%); and limited crops can be planted (0.8%). On the contrary, after UGM and others have been establishing *C. equisetifolia* since October 1996, a changing occurs and affects on agricultural land in the seventeenth coast (shown in Table 1). Rows formation of *C. equisetifolia* was typically used for wind barrier to prevent agricultural land, embankment, and fishing villages from wind erosion and salt spray [8] [14] (Fig. 5 and Fig. 10). Some previously studies have verified that the speed of sea wind was slowed down, the sand was stabilized and micro climate was created [8] [10] [17] [31]. Reference [31] also recorded that more space created behind rows formation for new agricultural land that previously undeveloped, especially in Pandansari Beach, Kuwaru Beach and part of Pandansimo Beach, Bantul Regency.

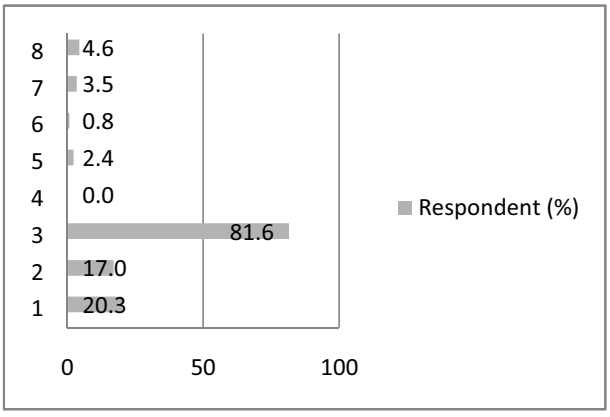


Figure 8. Agricultural problems found in the Southern Coast of Special Region of Yogyakarta before the establishment of *C. equisetifolia.* (Number in the left axis is problem types: 1. uncultivated land close to coast, 2. agricultural crops die because of salt water, 3. strong wind in the agricultural land, 4. more fertilizer needed, 5. difficult to obtain water, 6. limited crops can be planted, 7. sandy agriculture land, 8. others)

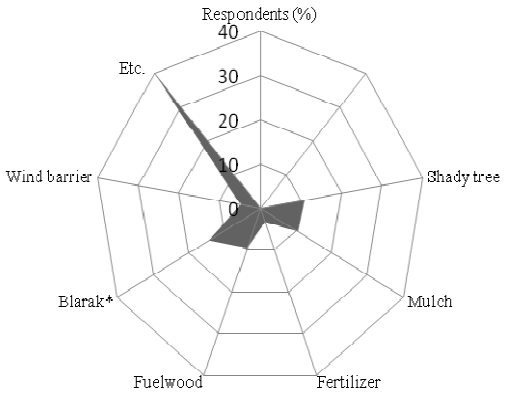


Figure 9. The use of *C. equisetifolia* on the agricultural land in the Southern Coast of Yogyakarta (*: a dried coconut leaf)

Today *C. equisetifolia* in the Southern Coast of Special Region of Yogyakarta is not only for wind break, but also provides other purposes. Respondents in Bugel Beach, Trisik Beach and Conggot Beach, Kulon Progo Regency stated that long vegetative wind barrier of *C. equisetifolia* also enable to reduce the use of dried coconut leaf (*blarak*), which importantly used from generation to generation in the agricultural land (14.5%) as shown below in Fig. 10 and Fig. 11. Moreover as shady tree for nursery (10.9%), mulch (10.4%), fertilizer (3.3%), and many kinds (49.4%).

Figure 10. (a) The use of a dried coconut leaf (*blarak*) for wind break; (b) a dried coconut leaf for shading nursery in Bugel Beach, Kulon Progo Regency; (c) *C. equisetifolia* has been begining to replace *blarak* on the agricultural land in Pandansimo Beach, Bantul Regency (photograph taken by Atus Syahbudin in March 2012)

Reduction in the use of *blarak*, purchased fertilizer and mulch during crops plantation will increase farmer's income because they can reduce the costs of labor who install the *blarak,* chemical fertilizer and mulch. Coastal agriculture, which cultivated in barren condition, needs more maintenance and supervision compare than field agriculture. Thus the reduction of agricultural resources requirement will be significant in reducing the cost [9]. Indeed vegetative wind barrier will also increase agricultural production because creates suitable micro climate that conditioned by *C. equisetifolia*'s stand. Finally crops can grow in better condition and more productive.

Nowadays in order to conserve *C. equisetifolia* still alive and spread widely, some coastal farmer groups (*kelompok tani*) initiate a local rules as a social rule that must be obeyed by all members. Their social bond seems very strong to obey their own rule and take a punishment. According Fig. 10 we also recorded that 9.6% respondents used dried branch of *C. equisetifolia* for fuelwood. Although this activity is allowed as far as a dried part, coastal farmer group should be carefull and gives more attention. Inhabitant maybe will find looppholes because of the economic pressure [2] [9]. The presence of *C. equisetifolia* in individual, which allowed artifially prunning from the middle to the lowest branch, also gives rise to a grey area. An area where there is an uncertainty whether people is disobey the rules of coastal farmer groups or not. This condition cause difficulty to apply the punishment. Moreover, if the defendant argue that they do not know the local rules or the benefits of *C. equisetifolia*, in addition to fuelwood.

It seems that ignorance of the benefits of *C. equisetifolia* associated with their experience to this species that closed relation with the age of *C. equisetifolia* plantation surrounding them. Fig. 12 shows that 45% respondents, 85% living in Gunungkidul, use directly *C. equisetifolia*. They are potentially to use the life part of *C. equisetifolia* to meet daily needs such as fuelwood. So that, government and NGO should develop the promotion and counseling to increase public knowledge and public awareness about *C. equisetifolia* and its benefit. Lesson learn from Lombang Beach in Madura Island, East Java Province or Samas Beach as the first establishment location of *C. equisetifolia* in Special Region of Yogyakarta Province could be a reference.

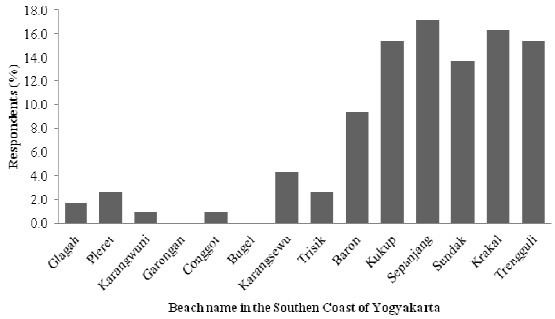


Figure 11. The number of respondents who used directly parts of *C. equisetifolia* in the Southern Coast of Special Region of Yogyakarta

Conclusion

C. equisetifolia becomes a well-known species in the Southern Coast of Special Region of Yogyakarta Province because it provides benefits and useful function, mainly for agricultural land. It distributes in the twenty-six beaches, found in the rows formation (group) and another scattered as in individual. Rows formation typically used for windbreak to prevent agricultural land, embankment, and fishing villages. Whereas individual formation which artificially pruning from middle to the lowest branch has purposes as shady tree in trading area, parking area, wayside, rest area, and yard fishing villages as well as border tree in the agricultural land and villages.

Today there is an enhancement use of *C. equisetifolia* in the Southern Coast of Special Region of Yogyakarta, not only for wind break, but also provides other purposes. Local inhabitant has been starting to use this species to reduce the use of dried coconut leaf (*blarak*), for shady tree in the nursery, mulch, fertilizer, and others. Reduction in the use of *blarak*, purchased fertilizer and mulch will increase farmer's income because reduce the cost of labor, fertilizer and mulch. Indeed vegetative wind barrier will also increase agricultural production due to suitable micro climate that conditioned by *C. equisetifolia*. Government and NGO should develop the promotion and counseling to increase public knowledge and public awareness about *C. equisetifolia* plantation and its many benefits, not only for fuelwood.

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References

[1] R. Dahuri, "Coastal Zone Management and Transmigration in Indonesia," International Workshop on Integrated Coastal Management in Tropical Developing Countries: Lessons Learned from Successes and Failures, 24–28 May 1996, Xiamen, Peoples Republic of China.

[2] S. Sukardjo, "Integrated Coastal Zone Management (ICZM) in Indonesia: A View from a Mangrove Ecologist," Southeast Asian Studies, vol. 40, 2002, pp. 200-218.

[3] M. L. Schwartz, Encyclopedia of Coastal Science. The Netherlands: Springer, 2005.

[4] E. B. Hardiyanto and M. Na'iem, "Present Status of Conservation, Utilization and Management of Forest Genetic Resources in Indonesia," Proc. Southeast Asian Moving Workshop on Conservation, Management and Utilization of Forest Genetic Resources. Forestry Department. In J. Koskela, S. Appanah, A. P. Pedersen, M. D. Markopolous (Eds.), Jakarta, Indonesia, 2001.

[5] T. Whitten, R. E. Soeriaatmadja and S. Afif, Ecology of Java and Bali, Singapore: Periplus, 2000.

[6] A. D. Setyawan, Indrowuryatno, Wiryanto, K. Winarno and A. Susilowati, "Mangrove Plants in Coastal Area of Central Java: 2. Floristic Composition and Vegetation Structure," Biodiversitas vol. 6, 2005, pp. 194-198.

[7] Central Statistics Agency, Bantul in Numbers, Indonesia: Bantul Regency Government, 2007.

[8] S. Hartono, Sukresno, S. A. Cahyono, E. Priyanto, and Gunarti, "Development of Rehabilitation Technique on Sandy Beach Land to Increase the Community Welfare," Proc. of BP2TPDAS-IBB Expose, Surakarta, 2004, pp. 23-36.

[9] A. D. Setyawan, K. Winarno and P. C. Purnama, "Conservation of Marginal Land Farming in South Areas of Yogyakarta," Enviro, vol. 4, No.1, 2004, pp. 1-7.

[10] Suhardi, Sutikno, H. H. Nurjanto, and M. A. Widodo, "*Casuarina equisetifolia* planting for rehabilitation of coastal and sand dune area," Proc. 11th International Workshop of BIO-REFOR, Seoul, Korea, 8-12 October 2002, pp. 143-150.

[11] Bantul Tourism Agency, Development of Basic Data, Tourism Object, Indonesia: Bantul Regency Government, 2004.

[12] Sumardi, "Prinsip Silvikultur Reforestasi dalam Rehabilitasi Formasi Gumuk Pasir di Kawasan Pantai Kebumen" Proc. National Seminar Field Rehabilitation Silviculture: The Development of Strategy for Controlling the High Rate of Forest Degradation, In S. Indrioko, E. Fariday, Budiadi, H. H. Nurjanto, Harjono, Widiyatno (Eds.), Universitas Gadjah Mada, Yogyakarta, November 24-25, 2008.

[13] H. Y. Siry, "Decentralized Coastal Zone Management in Malaysia and Indonesia: A Comparative Perspective," Coastal Management, vol. 34, 2006, pp. 267–285.

[14] Sutikno, S. Padmowiyoto, and Sukresno, "Model of Integrated Conservation and Utilization of Michoriza as an effort to Increase Security and Productivity of Sandy Land in Southern Coastal Region, DIY. Research Report of RUT (Integrated Research) III, Ministry of Science and Technology Indonesia, 1998.

[15] A. Wismadi, M. Brussel, M. Zuidgeest, H. Sutomo, L. E. Nugroho, M. V. Maarseveen, "Effect of Neighbouring village conditions and infrastructure interdependency on economic opportunity: A case study of the Yogyakarta region, Indonesia," Computers, Environment and Urban Systems, 2012, in press.

[16] A.S. Widodo, "The Study of Farming System of Coastal Land in Bantul Regency," Proc. National Seminar: Dynamics of Agriculture and Rural Development: Challenges and Opportunity for Improving the Welfare of Farmers, Indonesia: Indonesian Center for Agriculture Socio Economics and Policy Studies, 2008, pp. 355-368.

[17] B. Harjadi and D. Octavia, "Applying of Soil Conservation Technique ata Sandy Coastal Areas for the Agro-Recreation," Info Hutan, vol. V No. 2, 2008, pp. 113-121.

[18] Y. Dommergues, "*Casuarina equisetifolia:* An Old-timer with a New Future," NFT Highlights 90-02, 1990.

[19] J. C. Doran and J. W. Turnbull, "Australian trees and shrubs: species for land rehabilitation and farm planting in the tropics," ACIAR Monograph No. 24, 1997.

[20] Suhardi, Casuarina L., Plant Resources of South-East Asia No. 5(3). Timber Trees: Lesser-know Timbers, In , M. S. M. Sosef, L. T. Hong, S. Prawirohatmodjo (Eds.) Leiden, Netherland: Backhuys Publisher, 1998, pp. 146-149.

[21] D. Joker, "*Casuarina equisetifolia* L.," Seed Leaflet No. 14, Danida Forest Seed Center, September 2000.

[22] P. Hanelt, Mansfeld's Encyclopedia of Agricultural and Horticultural Crops, The Netherlands: Springer, 2001, pp. 343.

[23] W.B. Setyawan, "Modern Sand Deposits of Fluvial, Sandy Beach and Eolian Environment at Yogyakarta, Southern Part of Central Java," Library of Bandung Institute of Technology (ITB), unpublished.

[24] UNOSAT, "Mt. Merapi, Indonesia Shaded Relief Overview Map," 2006, unpublished.

[25] C. G . G . J. V. Steenis, Concise plant-geography of Java. In: C. A. Backer and R. C. Bakhuizen van den Brink, Jr., Flora of Java. Vol. II. Groningen: P.Noordhoff, 1965.

[26] PUSPICS, "Map of Direction and Speed of the Wave, Yogyakarta Province," 2002, unpublished.

[27] E. A. Rugayah, Widjaya and Praptiwi, Guide of Flora Biodiversity Data Collection, Indonesia: Center of Biology Research, LIPI, Bogor, 2004.

[28] D. A. Hill, M. Fasham, G. Tucker, M. Shewry and P. Shaw, Handbook of biodiversity methods: survey, evaluation and monitoring, UK: Cambridge University Press, 2005, pp. 219-222.

[29] D. G. Abbas, E. Mathias, A. R. J. Montes, P. Mundy, J. P. Ronquillo and T. Willard, Recording and Using Indigenous Knowledge: A Manual, Philippines: International Institute of Rural Recontruction (IIRR), 1995.

[30] S. A. Castillo and P. Moreno-Casasola, "Coastal sand dune vegetation: an extreme case of species invasion," Journal of Coastal Conservation 2, 1996, pp. 13-22.

[31] A. Syahbudin, K. Osozawa, I. Ninomiya, and D. T. Adriyanti, "The Distribution of Cemara Udang (*Casuarina equisetifolia*) and its Utilization along the Southern Coast of Bantul, Yogyakarta," Proc. JSPS-VCC Core University Program, International Seminar on Wetland and Sustainability, 26-28 June 2009 – Wetland and Climate Change: The Needs for Integration, Kinabalu, Sabah, IIUM, pp. 173-182.

[32] W. D. Atmanto, W.W. Winarni and Sumardi, "The Development of the Symbiotic on Cemara Udang Seedling after Planted at Various of Site Condition in Coastal Area," 2003, Library of Universitas Gadjah Mada, unpublished.

[33] F. Halle and R. A. A. Oldeman, "An Essay on the Architecture and Dynamics of Growth of Tropical Trees," Malaysia: Universiti Malaya, 1975.

[34] K. Pinyopusarerk, A. Kalinganire, E. R. Williams, and K. M. Aken, "Evaluation of International Provenance Trials of *Casuarina equisetifolia*," Australia: ACIAR, 2004.

[35] The Environment Protection Agency, "Function, Characteristics and Zonation of Dune Vegetation," 2007, Australian Government, report.